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# CALCULATION OF LEAKAGE THROUGH APERTURES ON COAXIAL CABLE BRAIDED SCREENS

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**ABSTRACT**: In this paper the more accurate calculation of the direct leakage of magnetic field through the diamond shaped holes is shown by using an early work [1] on the planar mesh surfaces. The exact geometry of the diamond shaped holes is taken into account. The details of the calculation are shown step by step.

## INTRODUCTION

The braid structure made by strands of helically interwoven wires and there are diamond shaped holes at the crossing point of the strands. Since the braid structure includes diamond shaped apertures, some of the magnetic flux lines penetrate from these apertures through to the interior conductor. Leakage from the apertures on the braid surface is calculated in literature by making some assumptions on the hole geometry [2]. The most famous one is assuming the diamond shaped geometry as an elliptical aperture. With this assumption it is possible to use the elliptical functions on the calculation. On the other hand, Ikrath [1] done a detailed calculation on the exact geometry of the diamond shaped apertures. But it is assumed that the cable surface is unlimited and planar. In real geometry, the geometry of the screen surface is cylindrical and in limited size. We modified the results of Ikrath by taking into account the exact geometry of the cable.

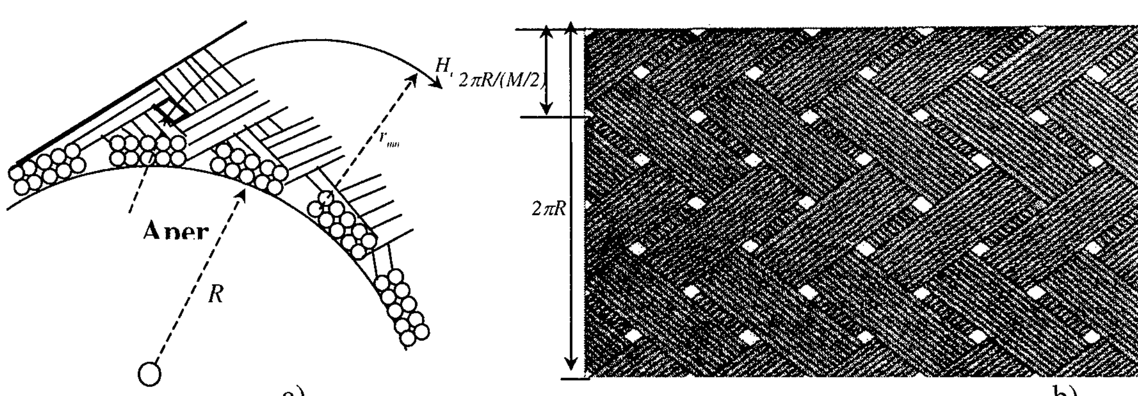
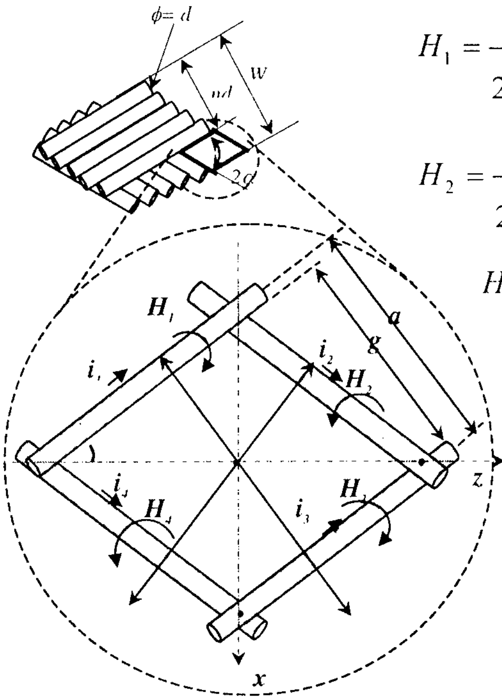



Fig.1. a) H field on aperture from single wire. b) Braid geometry on planar form

## Magnetic Field Leakage on Cylindrical Braid Geometry

Coaxial braid structure includes $M$ carriers and in each carrier there are $N$ wires (Fig.1). It is assumed that the total disturbing current, $I$ , flows from each wires equally ($i=I/MN$). The normal component of surface magnetic field to the hole surface is calculated by superposition of each single wire to the hole center. As a first step we consider only the effect of the nearest wires to the hole center. (Fig.2).




$$H_1 = \frac{i}{2\pi(\frac{a}{2}+\eta)} \qquad H_3 = \frac{-i}{2\pi(\frac{a}{2}-\eta)} \qquad \frac{-g}{2} \langle \eta \langle \frac{g}{2}$$

$$H_2 = \frac{i}{2\pi(\frac{a}{2}+\xi)} \qquad H_4 = \frac{-i}{2\pi(\frac{a}{2}-\xi)} \qquad \frac{-g}{2} \langle \xi \langle \frac{g}{2} \quad (1)$$

$$H_{1234} = H_1 + H_2 + H_3 + H_4$$

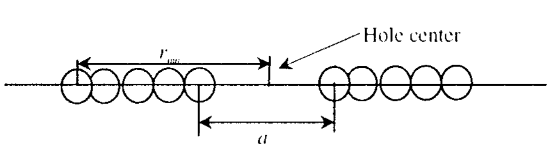
$$= \frac{-4i}{\pi}\left(\frac{\xi}{a^2-4\xi^2} + \frac{\eta}{a^2-4\eta^2}\right)$$

$$W = 4\pi R \frac{\cos\alpha}{M} \qquad g = W - Nd \qquad (2)$$

$$\xi = \frac{x}{2\cos\alpha} - \frac{z}{2\sin\alpha} \qquad \eta = \frac{x}{2\cos\alpha} + \frac{z}{2\sin\alpha} \quad (3)$$

Fig.2. H field near the diamond shaped aperture

On the z-axis, the total magnetic field distribution is zero. In the diamond-shaped aperture, the total H-field can be calculated by summing up the four H-fields originating from the nearest wires (1). Since the H field is normal to the current direction, we have to define new axis as and normal to the each wire direction. Aperture size is related with braid geometry (2) and perpendicular axis to the wires could be transformed from x-z plane by (3). In order to find the whole wire's H field to the aperture center, it is necessary to formulate the distance from the any wires to the aperture center (Fig.3) (4). At the center along the z-axis, each H fields cancel each other. By the way the magnetic field lines enter to the inside of the interior layer from the upper triangular part of the z axis and go out from the lower part. Since the H fields must close around themselves a rotation occurs around the z-axis. Therefore, there is an e.m.f. produced per unit length of the z axis [1]. In Fig.4, the more detailed geometry for the circular form is given. The radial distance on the circular surface of the braid from any wire to the aperture center should be converted to the shortest distance as in (7). The radial distance is equal to the $r_{mn}$ and shortest distance is equal to the $R_{mn}$ .

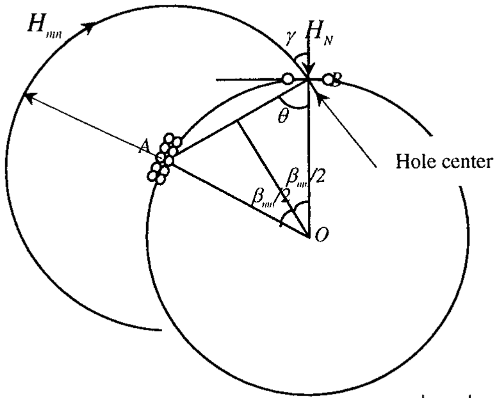



$$r_{mn} = (m-1)W + (n-1)d + \frac{W-(N-1)d}{2} \quad (4)$$

Fig.3. Distance from any wire to the aperture center in planar form.

For the total H field distribution in any point on the diamond shaped aperture, the effects from the all wires should be summed referred to the circular geometry (8). This

total term can be simulated via numerical calculation for digitized $\eta$ and $\xi$ axis points (Fig.5).

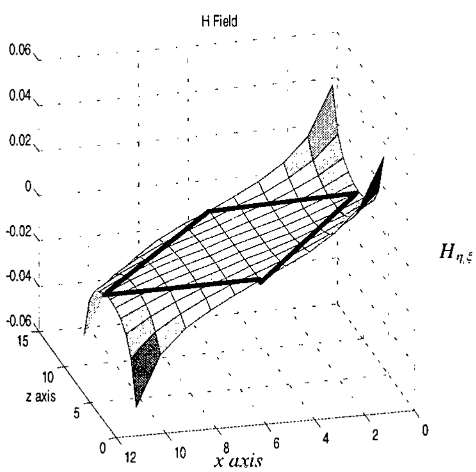



$$\gamma = \frac{\pi}{2} - \theta, \qquad \theta = \frac{\pi}{2} - \frac{\beta}{2} \Rightarrow \gamma = \frac{\beta}{2} \tag{5}$$

$$\vec{H}_N = \vec{H}_{mn}.ds \Rightarrow H_N = H_{mn}\cos\gamma \tag{6}$$

$$R_{mn} = |AB| = 2R\sin\frac{\beta_{mn}}{2} \qquad \beta_{mn} = \frac{r_{mn}}{R} \quad (in \quad radian) \tag{7}$$

Fig.4.Distance from any wire to the aperture center in circular form.




$$H_{\eta,\xi} = \frac{1}{2\pi}\cos\left(\frac{r_{mn}}{2R}\right)$$
$$\sum_{m=1}^{M/4}\sum_{n=1}^{N}\left[\frac{1}{R_{mn}+\eta} - \frac{1}{R_{mn}-\eta} + \frac{1}{R_{mn}+\xi} - \frac{1}{R_{mn}-\xi}\right] \tag{8}$$

Fig.5. Simulated value of H field. The values out of the border of the diamond shall be omitted.(M=24, N=8, d=0.15mm, i= 1Amp $\alpha=\pi/6$)

## CONCLUSION

The direct magnetic leakage term of the diamond shaped apertures of the coaxial braided screen are modified for the real geometric conditions of the cylindrical shield structure as if including the curvature and the limited number of the wires. One can calculate the total H field leakage by using this field distribution on one aperture, multiplying the hole number in unit length.

## REFERENCES

[1] K. Ikrath, *Leakage of Electromagnetic Energy from Coaxial Cable Structures*, US Army and Signalling Engineering Laboratories, Fort Monmouth, NJ, December 1957.

[2] H. Kaden, *Wirbelströme und Schirmwirkung in der Nachrichtentechnik*, Berlin, Springer, 1959.